WHAT IS CLAIMED IS:

1. A system for controlling particle accelerators, comprising: a distributed control system that further comprises: a computing device operable to execute a first software tool that identifies variable inputs and controlled variables associated with the particle accelerator, wherein at least one variable input is a manipulated variable input, and wherein said first software tool is further operable to determine relationships between said variable inputs and said controlled variables; and at least one input/output controller operable to monitor said variable inputs and tune said manipulated variable to achieve a desired controlled variable value.

2. The system for controlling particle accelerators of Claim 1, wherein said relationships between said variable input parameters and said controlled variables comprises a first principle models wherein said first principle model is dependent on said variable inputs.

3. The system for controlling particle accelerators of Claim 1, further comprising neural networks utilized to identify said variable inputs.

4. The system for controlling within particle accelerators of Claim 1, wherein said step of determining relationships

between said variable inputs and said controlled variables utilizes a combination of physical models and empirical methods.

5. The system for controlling particle accelerators of Claim 4, wherein said physical models and empirical methods are combined in series.

6. The system for controlling particle accelerators of Claim 4, wherein said physical models and empirical methods are combined in parallel.

7. The system for controlling particle accelerators of Claim 4, wherein said physical model varies over an operating range..

8. The system for controlling particle accelerators of Claim 5, wherein said physical model is a function of said variable inputs.

9. The system for controlling particle accelerators of claim 7, wherein said physical model comprises first principle parameters which vary with said variable inputs, wherein empirical methods comprise a neural network used to identify first principle parameters values associated with said variable inputs, and wherein said neural network

updates said first principle parameters with values associated with said variable inputs.

10. The system for controlling particle accelerators of Claim 9, wherein said neural network is trained.

11. The system for controlling particle accelerators of Claim 9, wherein said neural network is trained according to at least one method selected from the group consisting of: gradient methods, back propagation, gradient-based nonlinear programming methods, sequential quadratic programming, generalized reduced gradient methods, and non-gradient methods.

12. The system for controlling particle accelerators of Claim 11, wherein gradient methods require gradients of an error with respect to a weight and bias obtained by numerical derivatives.

13. The system for controlling particle accelerators of Claim 11, wherein gradient methods require gradients of an error with respect to a weight and bias obtained by analytical derivatives.

14. The system for controlling particle accelerators of Claim 10, wherein said controlled variablecomprises a magnetic field strength, shape, location and/or orientation and said

controlled variable comprises particle positions within said particle accelerator.

15. The system for controlling nonlinear control problems within particle accelerators of Claim 14, wherein said step of tuning said manipulated variable comprises adjusting a connector magnet and/or quadrupole magnet.

16. A dynamic controller for controlling the operation of a particle accelerator by predicting a change in the dynamic variable input values to the process to effect a change in the output of the particle accelerator from a current output value at a first time to a different and desired output value at a second time to achieve more efficient collisions between particles, comprising:

a dynamic predictive model for receiving the current variable input value, wherein said dynamic predictive model changes dependent upon said input value, and the desired output value, and wherein said dynamic predictive model produces a plurality of desired controlled variable values at different time positions between the first time and the second time to define a dynamic operation path of the particle accelerator between the current output value and the desired output value at the second time; and

an optimizer for optimizing the operation of the dynamic controller over a plurality of the different time positions in accordance with a predetermined optimization method that optimizes the objectives of the dynamic controller to achieve a desired path, such that the objectives of the dynamic predictive model vary as a function of time.

17. The dynamic controller of claim 16, wherein said dynamic predictive model comprises:

a dynamic forward model operable to receive variable input values at each of said time positions and map said variable input values to components of said dynamic predictive model associated with said received variable input values in order to provide a predicted dynamic output value;

an error generator for comparing the predicted dynamic output value to the desired output value and generating a primary error value as the difference for each of said time positions;

an error minimization device for determining a change in the variable input value to minimize the primary error value output by said error generator;

a summation device for summing said determined variable input change value with an original variable input value, which original variable input value comprises the variable input value before the determined change therein, for a

plurality of time position to provide a future variable input value as a summed variable input value; and

a controller for controlling the operation of said error minimization device to operate under control of said optimizer to minimize said primary error value in accordance with said optimization method.

18. A method for controlling particle accelerators, comprising the steps of:

identifying variable inputs and controlled variables associated with the particle accelerator, wherein at least one variable input parameter is a manipulated variable;

determining relationships between said variable inputs and said controlled variables wherein said relationship comprises models, and wherein parameters within said model are dependent on said variable inputs; and

tuning said manipulated variable to achieve a desired controlled variable value.

19. The method of Claim 18, wherein said step of identifying parameters utilizes neural networks to identify said parameters.

20. The method of Claim 18, wherein said step of identifying parameters utilizes neural networks that identify said parameters when an operating region changes.

21. The method of Claim 18, wherein said step of identifying parameters utilizes neural networks that identify said parameters.

22. The method of Claim 18, wherein said step of determining relationships between said variable inputs and said controlled variables utilizes a combination of physical models and empirical methods.

23. The method of Claim 22, wherein said physical models and empirical methods are combined in series.

24. The method of Claim 22, wherein said physical models and empirical methods are combined in parallel.

25. The method of Claim 22, wherein said physical model varies over an operating range.

26. The method of Claim 25, wherein said physical model is a function of said variable inputs.

27. The method of Claim 26, wherein said physical model comprises first principle parameters which vary with said variable inputs, wherein empirical methods comprise a neural network used to identify first principle parameter values associated with said variable inputs , and wherein

said neural network updates said first principle parameters with values associated with said variable inputs.

28. The method of Claim 27, wherein said neural network is trained.

29. The method of Claim 28, wherein said neural network is trained according to at least one method selected from the group consisting of gradient methods, back propagation, gradient-based nonlinear programming (NLP) methods, sequential quadratic programming, generalized reduced gradient methods, and non-gradient methods.

30. The method of Claim 29, wherein gradient methods require gradients of an error with respect to a weight and bias obtained by either numerical derivatives or analytical derivatives.

31. The method of Claim 18, wherein said manipulated variable comprises a magnetic field strength, shape, location and/or orientation and said controlled variable comprises particle positions within said particle accelerator.

32. The method of Claim 31, wherein said step of tuning said manipulated variable comprises adjusting a connector magnet.

33. The method of Claim 31, wherein said step of tuning said manipulated variable comprises adjusting and quadrapole magnet.

34. The method of Claim 31, wherein said step of tuning said manipulated variable comprises adjusting a connector magnet and quadrapole magnet.